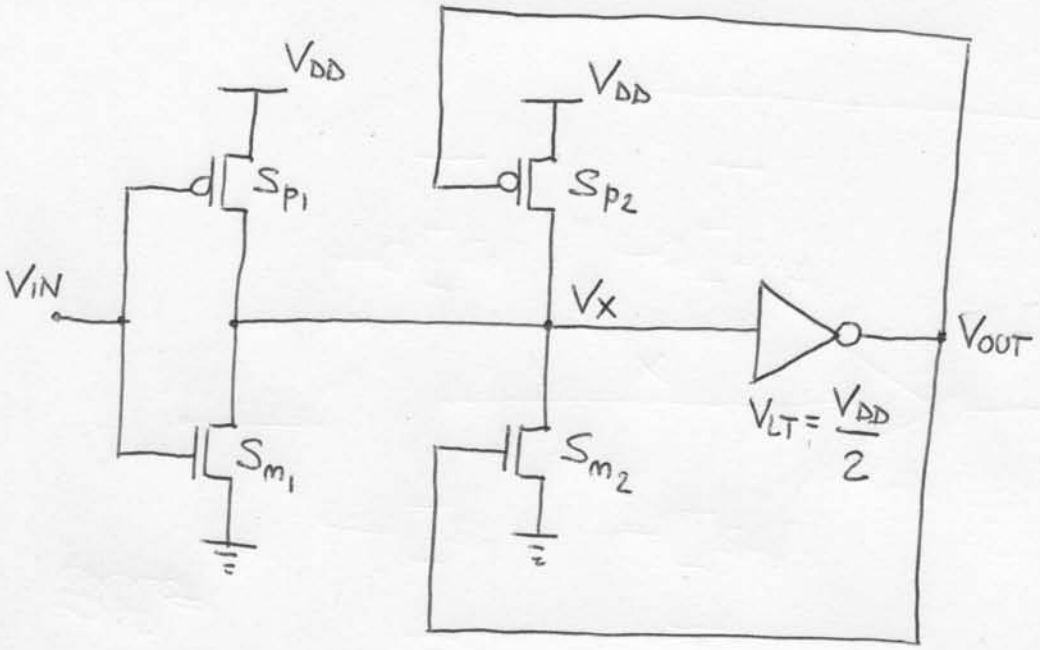


$V_{DD} = 3{,}3\,V$

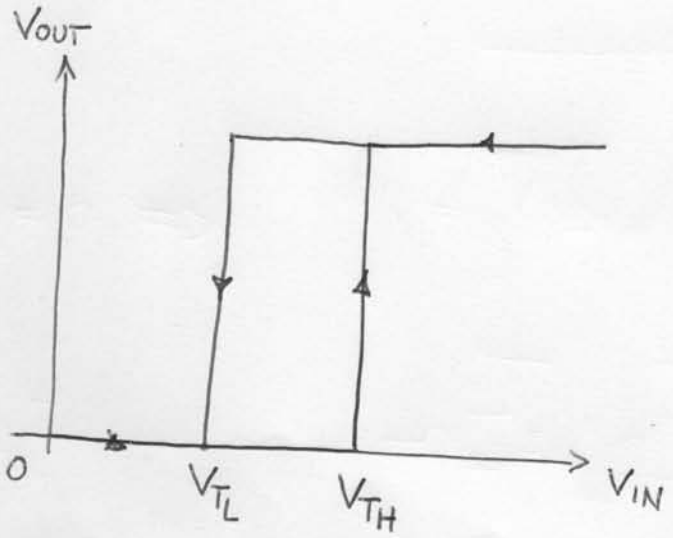
$V_{T_m} = |V_{T_p}| = 0{,}7\,V$

$\beta'_m = 100\ \frac{\mu A}{V^2}$

$\beta'_p = 50\ \frac{\mu A}{V^2}$

$S_{m_2} = 2$

$S_{P_2} = 4$



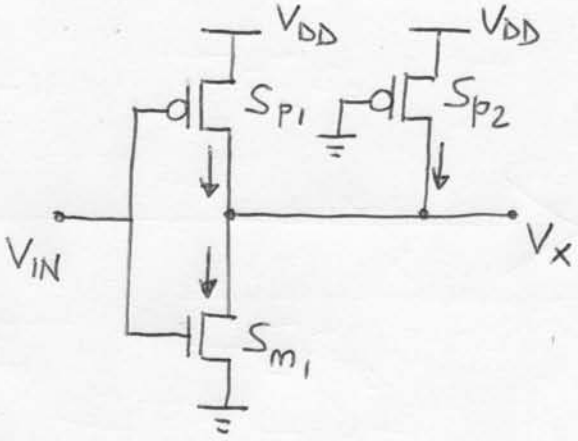
$V_{T_L} = 1{,}2\,V$

$V_{T_H} = 1{,}9\,V$

DIMENSIONARE N_1 e P_1.

$V_{IN} = 0 \longrightarrow V_X = V_{DD}$ $\quad V_{OUT} = 0$

$V_{IN} \uparrow$



Il circuito scatta quando $V_X = V_{LT}$

Si ha per $V_{IN} = V_{T_H}$

$$\begin{cases} V_{GS_{N_1}} - V_{T_N} = V_{T_H} - V_{T_N} = 1{,}9 - 0{,}7 = 1{,}2\,V \\ V_{DS_{N_1}} = V_{LT} = 1{,}65\,V \end{cases} \Rightarrow N_1 \text{ SATURO}$$

$$\begin{cases} V_{SG_{P_1}} - |V_{T_P}| = V_{DD} - V_{T_H} - |V_{T_P}| = 3{,}3 - 1{,}9 - 0{,}7 = 0{,}7\,V \\ V_{SD_{P_1}} = V_{DD} - V_{LT} = 1{,}65\,V \end{cases} \Rightarrow P_1 \text{ SATURO}$$

$$\begin{cases} V_{SG_{P_2}} \overset{-|V_{T_P}|}{=} V_{DD} - 0 - |V_{T_P}| = 2{,}6\,V \\ V_{SD_{P_2}} = V_{DD} - V_{LT} = 1{,}65\,V \end{cases} \Rightarrow P_2 \text{ TRIODO}$$

$$I_{DS_{N_1}} = \frac{\beta_{m_1}}{2}\left(V_{T_H} - V_{T_N}\right)^2 = \frac{\beta'_m S_{m_1}}{2} \cdot 1{,}44$$

$$I_{SD_{P_1}} = \frac{\beta_{P_1}}{2}\left(V_{DD} - V_{T_H} - |V_{T_P}|\right)^2 = \frac{\beta'_P S_{P1}}{2} \cdot 0{,}49$$

$$I_{SD_{P_2}} = \frac{\beta_{P_2}}{2}\left[2\left(V_{DD} - 0 - |V_{T_P}|\right)\cdot\left(V_{DD} - V_{LT}\right) - \left(V_{DD} - V_{LT}\right)^2\right] =$$

$$= \frac{\beta'_P S_{P2}}{2}\left[2 \cdot 2{,}6 \cdot 1{,}65 - 2{,}7225\right] = \frac{\beta'_P S_{P2}}{2} \cdot 5{,}8575$$

$$I_{DSN_1} = I_{SDP_1} + I_{SDP_2} \qquad \beta'_m = 2\,\beta'_p$$

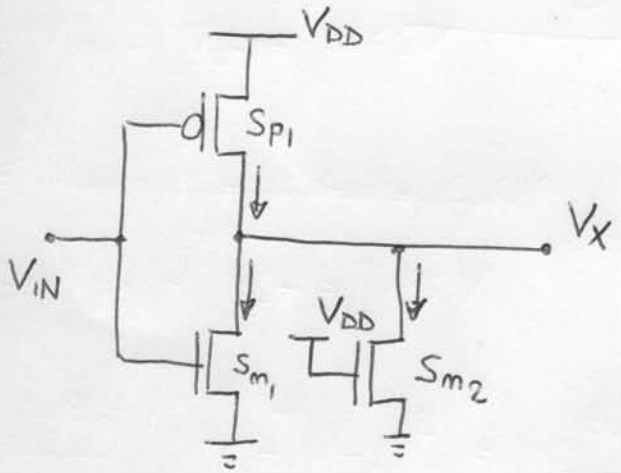
$$\frac{\beta'_p}{2}\left(2{,}88\, S_{m_1}\right) = \frac{\beta'_p}{2}\left(0{,}49\, S_{p_1} + 5{,}8575\, S_{p_2}\right)$$

$$2{,}88\, S_{m_1} = 0{,}49\, S_{p_1} + 5{,}8575\, S_{p_2}$$

S_{p_2}

$V_{IN} = V_{DD} \longrightarrow V_X = 0 \qquad V_{OUT} = V_{DD}$

$V_{IN} \downarrow$



Il circuito scatta quando $V_X = V_{LT}$

Si ha per $V_{IN} = V_{TL}$

$$\begin{cases} V_{GSN_1} - V_{TN} = V_{TL} - V_{TN} = 1{,}2 - 0{,}7 = 0{,}5\,V \\ V_{DSN_1} = V_{TL} = 1{,}65\,V \end{cases} \Rightarrow N_1 \text{ SATURO}$$

$$\begin{cases} V_{SGP_1} - |V_{TP}| = V_{DD} - V_{TL} - |V_{TP}| = 3{,}3 - 1{,}2 - 0{,}7 = 1{,}4\,V \\ V_{SDP_1} = V_{DD} - V_{LT} = 1{,}65\,V \end{cases} \Rightarrow P_1 \text{ SATURO}$$

$$\begin{cases} V_{GSN_2} = V_{DD} - V_{Tm} = 3{,}3 - 0{,}7 = 2{,}6\,V \\ V_{DSN_2} = V_{TL} = 1{,}65\,V \end{cases} \Rightarrow N2 \text{ TRIODO}$$

$$I_{DS N_1} = \frac{\beta_{N_1}}{2}\left(V_{TL} - V_{Tm}\right)^2 = \frac{\beta'_m S_{m_1}}{2}\ 0,25$$

$$I_{SD P_1} = \frac{\beta_{P_1}}{2}\left(V_{DD} - V_{TL} - |V_{TP}|\right)^2 = \frac{\beta'_P S_{P1}}{2}\ .1,96$$

$$I_{DS N_2} = \frac{\beta_{N_2}}{2}\left[2\left(V_{DD} - V_{Tm}\right)\cdot V_{LT} - V_{LT}^2\right] =$$

$$= \frac{\beta'_m S_{m2}}{2}\left[2\cdot 2,6\cdot 1,65 - 2,7225\right] = \frac{\beta'_m S_{m2}}{2}\cdot 5,8575$$

$$I_{SD P_1} = I_{DS N_1} + I_{DS N_2} \qquad \text{com} \qquad \beta'_m = 2\beta'_P$$

$$\frac{\beta'_P}{2}\left(1,96\ S_{P_1}\right) = \frac{\beta'_P}{2}\left(0,5\ S_{m_1} + 11,715\ S_{m_2}\right)$$

$$1,96\ S_{P1} = 0,5\ S_{m_1} + 11,715\ S_{m_2}$$

Se $S_{m_2} = 2$ $\quad S_{P2} = 4$

$$\begin{cases} 2,88\ S_{m_1} - 0,49\ S_{P_1} = 23,43 \\ 1,96\ S_{P_1} - 0,5\ S_{m_1} = 23,43 \end{cases}$$

$$3,38\ S_{m_1} - 2,45\ S_{P_1} = 0$$

$$S_{p_1} = \frac{3,38}{2,45} S_{m_1} = 1,3796\, S_{m_1}$$

$$2,88\, S_{m_1} - 0,49 \cdot \frac{3,38}{2,45} S_{m_1} = 23,43$$

$$2,204\, S_{m_1} = 23,43$$

$$S_{m_1} = 10,63$$

$$S_{p_1} = 14,665$$